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Nedwell

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(54) **DECODING TUMBLER LOCKS**

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E05B 19/20 (2006.01)

(52) **U.S. Cl.**
CPC ***E05B 19/205*** (2013.01)

(58) **Field of Classification Search**
CPC E05B 19/205
USPC 33/540
See application file for complete search history.

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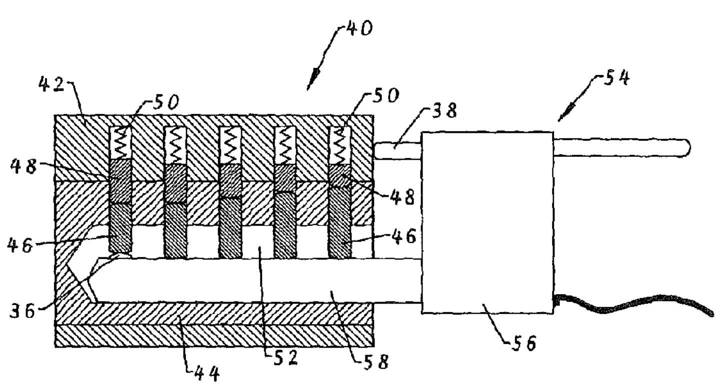
(57) **ABSTRACT**

In order to determine the particular cut possessed by a tumbler of a mechanical lock, the tumbler is stimulated with mechanical energy. The vibrational response of the tumbler is detected, and the detected response is used in determining which of the possible cuts the tumbler possesses. The cut of a lock tumbler is defined by its shape and/or size. For example, in the case of a pin tumbler lock, the cut of a pin is defined by its length. Different cuts of tumbler will therefore exhibit different vibrational responses to stimulation by mechanical energy, and these different vibrational responses can be used to determine which cut the tumbler possesses, for example by comparing with the vibrational responses of real or modeled tumblers with known cuts. The tumbler may be stimulated by an impulse of mechanical energy, and, after stimulating the tumbler, the vibrational response of the tumbler may be detected over a period of time.

16 Claims, 3 Drawing Sheets



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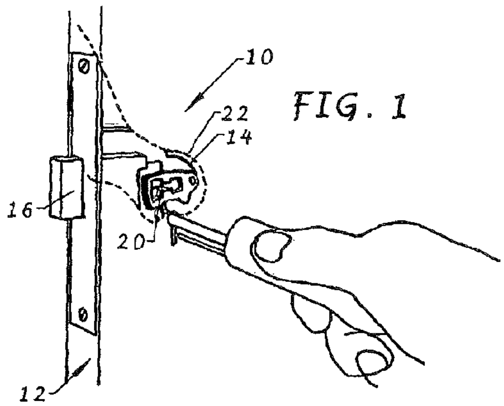
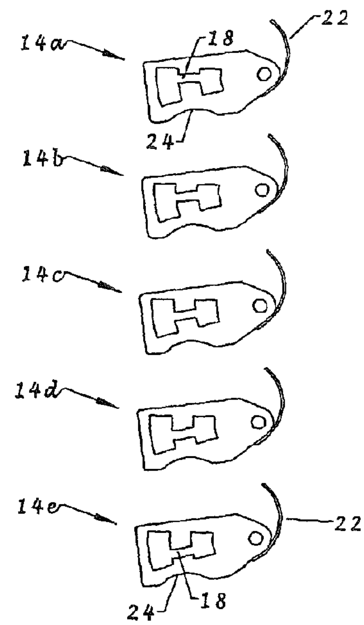


FIG. 1

FIG. 2



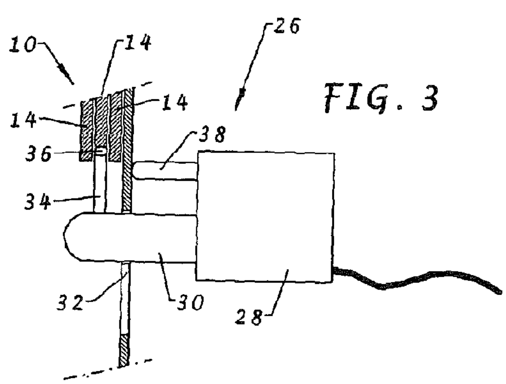


FIG. 3

FIG. 4

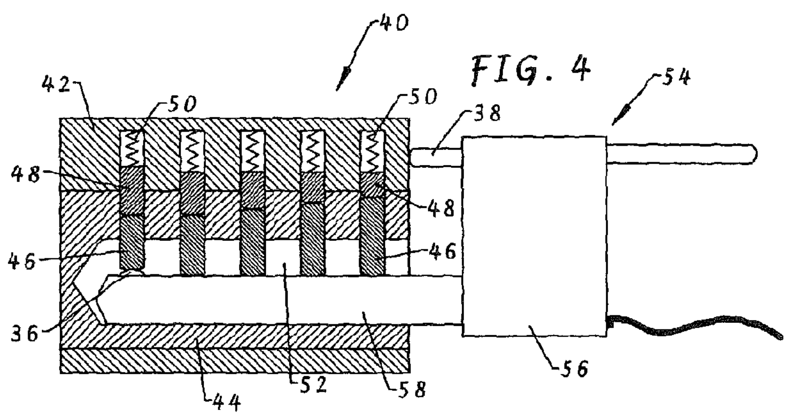


FIG. 5

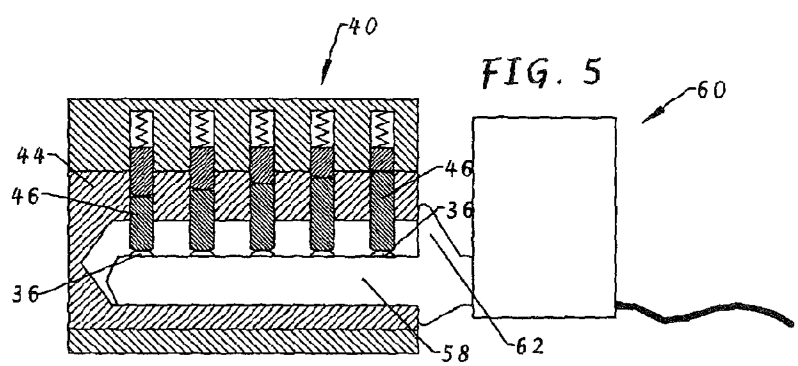
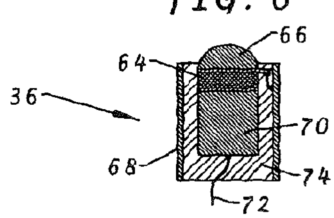


FIG. 6



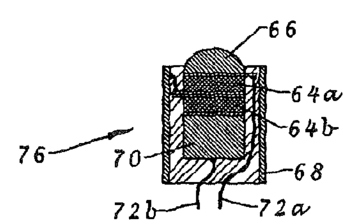


FIG. 7

FIG. 8

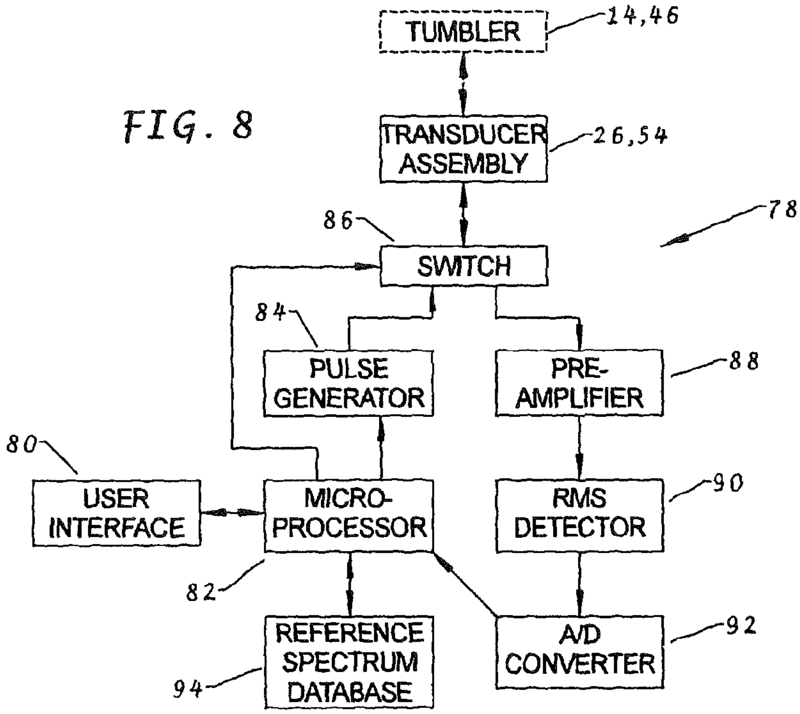
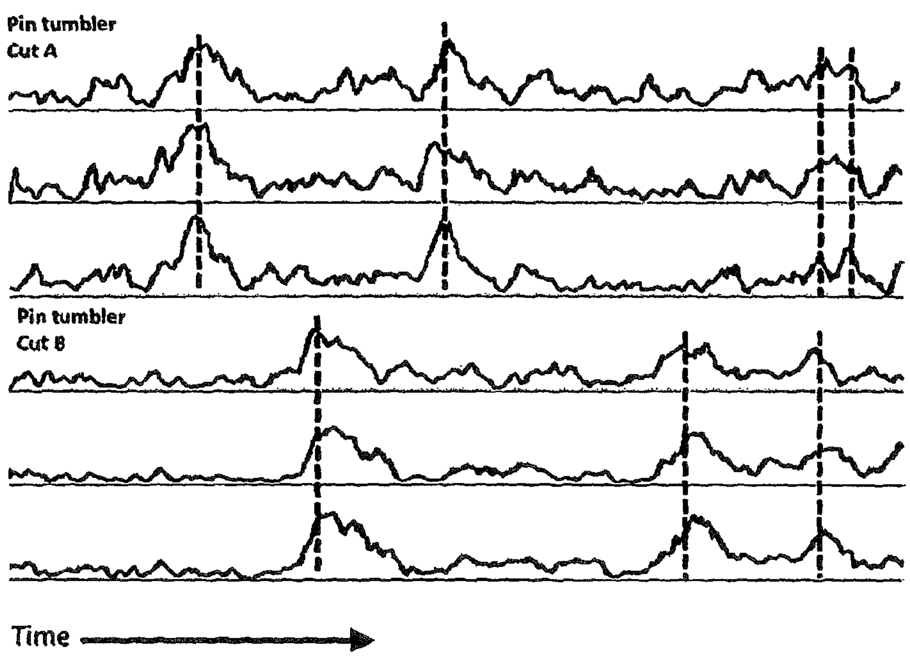

TUMBLER
14,46
TRANSDUCER ASSEMBLY
26,54
78
86
SWITCH
84
PULSE GENERATOR
PRE-AMPLIFIER
88
80
USER INTERFACE
MICRO-PROCESSOR
RMS DETECTOR
90
82
REFERENCE SPECTRUM DATABASE
A/D CONVERTER
92
94

FIG. 9


Pin tumbler
Cut A
Pin tumbler
Cut B
Time

DECODING TUMBLER LOCKS

CROSS-REFERENCE TO RELATED APPLICATION

This Application is a Section 371 National Stage Application of International Application No. PCT/GB2013/050358, filed 15 Feb. 2013 and published as WO 2013/124628 A1 on 29 Aug. 2013, in English, the contents of which are hereby incorporated by reference in their entirety.

This invention relates to a method, apparatus and transducer for use in determining the cut of a mechanical lock or of a tumbler in a mechanical lock.

The invention is applicable to a mechanical lock which is arranged to be unlocked by a key. In order to do this, first the key must be of a design which can be inserted into the lock. Second the key must have the correct 'cut' so that when fully inserted into the lock it moves at least one tumbler (but usually between three and nine tumblers) in the lock each to a position in which the lock can be released. Each tumbler has one of several possible cuts, typically between three and ten cuts. The combination of the particular cuts of the tumblers and the order in which they are arranged in the lock defines the cut of the lock, and the cut of the key needs to complement the cut of the lock in order that the key will work. Locks are usually designed so that it is not possible to read the cut of the lock by external visual inspection.

There are occasions when a lock needs to be lawfully unlocked but none of the keys for that lock is available, for example because they have all been lost. In this case, an attempt may be made by a skilled locksmith to pick the lock. If successful, the lock can then usually be replaced, or the lock can be disassembled so that its cut can be determined and the lock can be re-keyed. However, some locks are extremely difficult, or impossible, to pick. If a complete range of possible keys for a lock is available, each of them may be tried in the lock in turn until a key that works is found. However, the number of possible cuts of key for a particular design of lock may be very high, of the order of ten thousand, a hundred thousand, a million or more, and so in most cases this is an impracticable method. As a last resort, it may be necessary to break the lock or the structure to which it is fitted.

An aim of the invention, or least of specific embodiments of it, is to enable the cut of a locked lock to be determined without the need to pick the lock and without the need for dismantling the lock so that, for example, a key with a complementary cut can be manufactured and the lock can be unlocked.

The invention is applicable to many different types of lock, including pin-, wafer-, disc- and lever-tumbler locks.

In accordance with a first aspect of the present invention, there is provided a method of determining a particular cut possessed by a tumbler of a mechanical lock, the particular cut being one of a plurality of possible cuts. The method comprises the steps of: stimulating the tumbler with mechanical energy; detecting the vibrational response of the tumbler to the stimulation; and processing the detected response in determining which cut of the plurality of possible cuts the tumbler possesses.

The cut of a tumbler is defined by its shape and/or size. For example, in the case of a pin-tumbler lock, the cut of a pin is defined by its length. Different cuts of tumbler will therefore exhibit different vibrational responses to stimulation by mechanical energy, and these different vibrational responses can be used to determine which cut the tumbler possesses, for example by comparing with the vibrational responses of real or modelled tumblers with known cuts.

In a preferred embodiment of the invention, the tumbler is stimulated by an impulse of mechanical energy, and, after stimulating the tumbler, the vibrational response of the tumbler is detected over a period of time.

The method preferably includes the steps of: storing, for each possible cut, at least one reference time-domain response time history for that cut; producing from the detected response a detected time-domain response time history for the tumbler; and comparing the detected time history with the reference time history. In this case, each comparing step may use an algorithm which produces a quality-of-match value dependent on the quality of match between the detected time history and the respective reference time history; and the cut of the tumbler may be determined from which reference time history produces the best quality-of-match value. The quality-of-match value for each reference time history is preferably weighted in favour of peaks in the detected time history which match peaks in that reference time history. The quality-of-match value for each reference time history is also preferably weighted against peaks in the detected time history which do not match peaks in that reference time history and/or against peaks in that reference time history which do not match peaks in the detected time history. Each of the reference time histories is preferably normalised to a constant overall value prior to this matching, and the method may further comprise the step of normalising the detected time history prior to comparison with the stored time histories.

The stimulating step preferably comprises: providing a driving transducer which moves in response to an electrical driving signal; driving the driving transducer with an electrical pulse; and transmitting the resultant movement of the driving transducer to the tumbler.

The detecting step preferably comprises: providing a detecting transducer which generates an electrical detection signal in response to movement of the detecting transducer; and transmitting the vibrational response of the tumbler to the detecting transducer.

The driving transducer and the detecting transducer may be separate devices. However, a common transducer may conveniently serve as the driving transducer and as the detecting transducer.

The root mean square level of the detection signal is preferably used, and it may be smoothed over a short time period.

The invention extends, in a second aspect thereof, to a method of determining a cut of a mechanical lock having a plurality of tumblers each possessing one of a plurality of possible cuts. The method comprises the steps of performing the method of the first aspect of the invention on each of the tumblers. For a design of lock which is known other than its cut, once the cut of each of its tumblers has been determined, the cut of the lock as a whole and therefore of the required key can be determined.

A third aspect of the invention provides a transducer assembly for use in determining a particular cut possessed by a tumbler of a mechanical lock. The transducer assembly comprises: a shaft or blade for insertion into a keyhole of the lock; and at least one transducer mounted on the shaft or blade and arranged to stimulate the tumbler by an impulse of mechanical energy and to detect vibration of the tumbler. The transducer assembly may additionally include a gauge for gauging the depth to which the shaft or blade is inserted into the lock. When used with a lock having a plurality of tumblers, the shaft or blade can therefore be moved to align the transducer with the tumblers one after another. Alternatively, a plurality of such transducers may be provided arranged along the shaft or blade, and a register may be provided for engaging the lock and registering the transducer assembly with respect to the lock in the longitudinal direction of the shaft or blade so that the individual transducers become aligned with the individual tumblers.

In accordance with a fourth aspect of the invention, there is provided an apparatus for determining a cut of a tumbler of a mechanical lock. The apparatus comprises means for performing at least the stimulating step and the detecting step as defined for the method of the first aspect of the invention. At least part of the processing step of the method may be performed by a human operator. However, the apparatus may further comprise means for performing the processing step at least in part automatically. The apparatus preferably employs a transducer assembly according to the third aspect of the invention.

Specific embodiments of the present invention will now be described, purely by way of example, with reference to the accompanying drawings, in which:

FIG. **1** is a partly cut away view of a lever tumbler lock fitted to a door and a first embodiment of transducer assembly;

FIG. **2** shows a set of five possible cuts of lever tumbler which may be used in such a lock;

FIG. **3** is a schematic sectioned view through the lock and showing the transducer assembly;

FIG. **4** is a schematic sectioned view of a pin tumbler lock and a second embodiment of transducer assembly;

FIG. **5** is similar to FIG. **4**, but showing a third embodiment of transducer assembly;

FIG. **6** is a schematic sectioned view of one arrangement of transducers that may be used in the transducer assemblies;

FIG. **7** is a schematic sectioned view of another arrangement of transducer that may be used in the transducer assemblies;

FIG. **8** is a block diagram of a lock cut determining apparatus according to the invention; and

FIG. **9** shows sample signal time histories that may be acquired by the apparatus.

Referring to FIGS. **1** and **2**, a lever tumbler lock **10** fitted to a door **12** has a set of three lever tumblers **14** which normally prevent a bolt **16** from moving. However, each tumbler **14** has a gateway **18** through which a projection **20** from the bolt **16** can pass if the tumbler **14** is raised, against the action of a leaf spring **22**, a particular amount by a key bearing against the lower edge **24** of the tumbler **14**. Each tumbler **14** is identical to one of a set of five tumblers **14***a-e* as shown in FIG. **2**. The tumblers **14***a-e* are identical except that each has its gateway **18** at a different angular position. The tumblers **14***a-e* therefore need to be raised by differing amounts by the key in order to bring their gateways **18** horizontal so that the projection **20** on the bolt **16** can pass though them. This is what gives each of the tumblers **14***a-e* its different cut.

The invention utilises the effect that if each lever tumbler **14** of the lock **10** is stimulated mechanically at a position along its lower edge **24** that is accessible through the keyhole, then the tumbler **14** will respond differently in dependence upon which of the five cuts the tumbler **14** possesses. By detecting the response and comparing the response to predetermined reference responses for each of the five cuts of tumbler **14**, it is possible to determine which cut that tumbler **14** possesses. Once the cuts of all of the tumblers **14** have been determined and the order of them, then if the model of lock is known, it is possible to manufacture a key that will fit the lock.

FIG. **3** shows a transducer assembly **26** for stimulating the tumblers **14** in turn. The assembly **26** comprises a body **28**, a shaft **30** projecting from the body **28** so that it can be inserted through the keyhole **32** into the lock **10**, and an arm **34** mounted on the shaft **30** so that it too can be inserted through the keyhole **32**. The arm **34** radiates from the shaft **30** and has a transducer device **36** mounted at its tip so that when the shaft **30** is turned, for example through half a turn, the transducer device **36** can engage the lower edge **24** of one of the tumblers **14**, depending on how far the shaft **30** has been inserted into the lock **10**. To assist in setting or measuring the insertion distance, a depth gauge **38** is provided on the body **28**.

Referring to FIG. **4**, a different type of lock, namely a pin tumbler lock **40**, is schematically shown having a body **42** and a cylindrical plug **44** fitted in the body **42**. Five pairs of abutting pins **46**,**48** are a sliding fit in aligned holes in the body **42** and plug **44**, and the pins **46**,**48** are urged inwards by springs **50** so that the inner tumbler pins **46** project into a keyway **52** and so that the outer driver pins **48** rest partly in the body **42** and partly in the plug **44**. Although the total length of each pair of pins **46**,**48** is identical, the tumbler pins **46** can be of different lengths, as too can the driver pins **48**. It is the length of each tumbler pin **46** that defines its cut. In the example shown, there are five different cuts of the tumbler pins **46**. When a key (not shown) is fully inserted into the keyway **52** it raises each pair of pins **46**,**48** by individual amounts according to the cut of the key. If the keys fits, then the abutment line between each tumbler pin **46** and its driver pin **48** will line up with the outer surface of the plug **44** (the shear line), so that the plug **44** can then be turned in the body and operate an unlocking mechanism.

Again, the invention utilises the effect that if each tumbler pin **46** of the lock **40** is stimulated mechanically at its lower end that is accessible through the keyway **52**, then the tumbler pin **46** will respond differently in dependence upon which of the five cuts the tumbler pin **46** possesses. By detecting the response and comparing the response to predetermined reference responses for each of the five cuts of tumbler pin **46**, it is possible to determine which cut that tumbler pin **46** possesses. Once the cuts of all of the tumbler pins **46** have been determined and the order of them, then if the model of lock is known, or even if it is not, it is possible to manufacture a key that will fit the lock.

FIG. **4** also shows a transducer assembly **54** for stimulating the tumbler pins **46** in turn. The assembly **54** comprises a body **56** and a blade **58** projecting from the body **56** so that it can be inserted into the keyway **52**. A transducer device **36** is mounted on the blade **58** so that it can engage the lower end of any one of the tumbler pins **46**, depending on how far the blade **58** has been inserted into the lock **40**. To assist in setting or measuring the insertion distance, a depth gauge **38** is provided on the body **56**.

FIG. **5** shows an alternative transducer assembly **60** for stimulating the tumbler pins **46** of the lock of FIG. **4**. In this case, a separate transducer device **36** is provided for each tumbler pin **46**. A depth gauge **38** is therefore unnecessary, but the blade **58** is formed with a fixed register **62** which engages the end of the plug **44** of the lock **40** when the blade **58** is in its proper position.

The transducer device **36** used in the transducer assemblies **26**,**54**,**60** of FIGS. **3** to **5** may comprise an element **64** of a piezoelectric material, a magnetostrictive material, or another material which changes shape when a voltage or other signal is applied to it.

One design of transducer device **36** is shown in FIG. **6**. In the simplest case, the element **64** is placed in contact with the tumbler **14**,**46**, so that the vibration of the element **64** may be transferred to the tumbler **14**,**46** and vice versa. However, since this may cause wear of the element **64**, and also to improve the transmission of energy, the vibration may be transferred between the element **64** and the tumbler **14**,**46** through a thin layer of compliant material and/or an anvil **66**, or hard structure, attached to the outer face of the element **64**, which is designed to couple movement efficiently between the transducer element **64** and the tumbler **14**,**46**. As shown in FIG. **6**, the device **36** has an electrically conductive tubular sleeve **68** to which a ‘ground’ electrode of the element **64** is bonded, and an electrically conductive backing mass **70** which is bonded to the ‘signal’ electrode of the element **64** and also provides a connection for a signal cable **72**. The element **64** and backing mass **70** are potted in the sleeve **68** by a non-conductive material **74** such as plastic or rubber which may additionally serve to insulate the element **64** from the shaft **30** or blade **58** of the transducer assembly **26**,**54**,**60**.

Another design of the transducer device **76** is shown in FIG. **7**. In this case, there are two transducer elements **64***a,b*, namely a receiving transducer element **64***a* immediately underneath the anvil **66**, and a transmitting transducer element **64***b* sandwiched between the receiving element **64***a* and the backing mass **70**. The abutting electrodes of the elements **64***a,b* are electrically bonded to the ground sleeve **68**, and separate receiving and transmitting signal cables **72***a,b* are electrically connected to the other electrode of the receiving element **64***a* and to the backing mass **70**.

An apparatus **78** for use in determining the cut of the lock **10**,**40** using a transducer assembly **26**,**54** with a transducer device **36** is shown schematically in FIG. **8**. In response to a command from a user interface **80**, a microprocessor **82** is programmed to trigger a pulse generator **84** to generate a voltage pulse and also to control a switch **86** so that the voltage pulse is passed from the pulse generator **84** to a transducer element **64** of a transducer device **36** (as described with reference to FIG. **6**) in the transducer assembly **26**,**54**. As a result, the tumbler **14**,**46** in contact with the transducer device **36** is stimulated by an impulse of mechanical energy. Immediately after the voltage pulse has finished, the microprocessor **82** controls the switch **86** so that the transducer element **64** is connected to the input of a preamplifier **88** which amplifies the voltage signal that it receives and passes it to a root-mean-square detector circuit **90**. The circuit **90** produces as an output a voltage signal which is the RMS level of the input signal, optionally smoothed over a short period of time. This RMS signal is then converted to a digital signal by an A to D converter **92**, and a stream of samples of the digital signal are input to the microprocessor **82**. The microprocessor **82** is then programmed to perform any of a number of operations on the received data stream, such as storing it, representing it in graphical form to the user interface **80**, and/or processing it and data in a reference time history database **94** so as to determine which cut is possessed by the tumbler **14**,**46** under test, as will be described in more detail below. The above process is then repeated for each of the other tumblers **14**,**46** in the lock **10**,**40**.

The pulse provided by the pulse generator is preferably a fixed voltage pulse of short duration, for example of about 0.01 microseconds, and as a result the tumbler **14**,**46** under test receives a mechanical impulse. The response of a tumbler **14**,**46** of a lock to such an impulse over a period of time after the impulse will typically be complex, and dependent on the detailed structure of the tumbler. However, it will be appreciated that for two tumblers **14**,**46** of identical cut, the vibrational behaviour of both will be identical, within the limits of manufacture. However two different tumblers **14**,**46** will generally produce different vibrational behaviours. Thus, if the vibrational behaviour of the various tumblers **14**,**46** of different cuts for a particular design of lock are previously recorded, or estimated using a suitable modelling programme, the unknown cut of a lock under test may be determined by comparison of the vibrational behaviour to the set of known behaviours.

FIG. **9** shows the outputs of the A to D converter **92** as a function of time after the stimulation pulse for six tumbler pins **46**. The upper three traces (or time-domain response time histories) are for pins of one cut, and the lower three time histories are for another cut. As can be seen, the time histories for pins which have the same cut are very similar However, the time histories for pins having different cuts are dissimilar. Hence, where a reference set of time-domain response time histories have been acquired for a particular lock type and all permissible cuts and therefore permissible pin lengths, having at least one example of each cut but preferably many, it is possible to determine the cut of an unknown lock by comparing the time-domain response time histories of the unknown pins within it to the reference set of time histories. By finding the cut of each pin that matches most closely to the known reference cuts, the cut of that pin may be determined.

In the simplest case, a trained operator of the apparatus **78** might simply recognise the response time history of a cut from previous experience. However, it is preferable to aid the operator in recognising the cut by visually comparing the response time history of the unknown cut against each reference time history. For instance, the reference and unknown time histories may be overlaid on the same graph, to determine whether the peaks, troughs, and other features of the reference and unknown time histories are similar. These features may be used by the operator to visually determine which reference cut matches the unknown cut best.

Alternatively, it is possible for the microprocessor **82** to use a suitable algorithm to compare the time history for the unknown pin and the reference time histories automatically. For instance, the unknown time history may be correlated against each of the reference time histories, to find the reference time history that provides the best match.

It should be noted that where the reference time histories have dissimilar levels, for instance if the contact between the transducer and the pin was better in one case than another when the signal was acquired, a matching algorithm may tend to favour a pulse having the highest level. Therefore, in order to compare the unknown time history more accurately and select those that offer the best matches, it is beneficial to normalise at least the reference time histories first, in order to bring the average amplitude of them all to the same level. For instance, in producing a normalised reference time history, the RMS signal output from the A to D converter **92** can be normalised by dividing it by the overall root mean square level of the entire time history for that time history. In other words, if a digital unnormalised reference time history is made up of N data points having values U(i) for I=1 to N, then the corresponding N data points having values R(i) in the normalised time history can be calculated as:

$$R(i) = \frac{U(i)}{\sum_{j=1}^{j=N} U(j)}$$

One suitable algorithm to find the quality of match Q between the N-point root mean square time history X(i) for an unknown tumbler and a normalised reference time history R(i) is given by:

$$Q=\Sigma_{i=1}^{i=N} X(i)\cdot R(i)$$

Thus, the microprocessor **82** multiplies each i-th point in the unknown time history by the corresponding point in the reference time history, and sums the values over all N point pairs. It will be appreciated that where peaks in both the reference and unknown time-domain time histories coincide, a high value will be multiplied by a high value and its addition to the quantity Q will be high, thus making it to tend to a large value. Where the peaks do not coincide, Q will be correspondingly low as in general a high value will be multiplied by a low value at each point. Thus, if the quantity Q is calculated using the unknown time history and for all of the reference time histories, it may be used to select the best match by determining the reference time history that yields the highest value of Q.

It may be noted that whereas this algorithm provides a high value for peaks that coincide, it does not provide a penalty when a peak occurs in the reference time history that does not exist in the unknown time history, and vice-versa. It may therefore be beneficial to use an algorithm which ensures that the match is the best possible, by not only ensuring that peaks in the unknown time history coincide with peaks in the reference time history, but also that no peaks exist in the unknown time history that are not matched by peaks in the reference time history and vice-versa. For instance, the degree of existence W_1 of unmatched peaks in the unknown time history when compared with the reference may be estimated by:

$$W_1 = \sum_{i=1}^{i=N} \frac{X(i)}{R(i)}$$

Similarly, the degree of existence W_2 of unmatched peaks in the reference time history when compared with the unknown time history is given by:

$$W_2 = \sum_{i=1}^{i=N} \frac{R(i)}{X(i)}$$

Thus, a corrected value of the quality of match Q' that penalises for unmatched peaks is given by

$$Q' = A \cdot Q - B \cdot W_1 - C \cdot W_2$$

where A, B and C are constants determined by experiment to give the best match.

Various modifications and developments may be made to the embodiments of the invention described above.

For example, it will be appreciated that the matching algorithms are provided by means of example, and there are many other algorithms which might be used to match the detected and reference time histories. The use of analysis systems such as neural networks may provide better matching.

Also, in the apparatus **78** of FIG. **8**, instead of using a transducer device **36** (FIG. **6**) in the assembly **26**,**54**, a transducer device **76** (FIG. **7**) may be employed. In this case, the switch **86** is omitted, and the output of the pulse generator **84** is directly connected to the transmitting element **64***b*, whereas the input to the preamplifier **88** is directly connected to the receiving element **64***a*.

It should be noted that the embodiments of the invention has been described above purely by way of example and that many other modifications and developments may be made thereto within the scope of the present invention.

The invention claimed is:

1. A method of determining a particular cut possessed by a tumbler of a mechanical lock, the particular cut being one of a plurality of possible cuts, the method comprising the steps of:

stimulating the tumbler by an impulse of mechanical energy;

detecting, over a period of time, the vibrational response of the tumbler to the stimulation; and

processing the detected response in determining which cut of the plurality of possible cuts the tumbler possesses.

2. A method as claimed in claim **1**, and including the steps of:

storing, for each possible cut, at least one reference time-domain response time history for that cut;

producing from the detected response a detected time-domain response time history for the tumbler, and

comparing the detected time history with the reference time histories.

3. A method as claimed in claim **2**, wherein:

each comparing step uses an algorithm which produces a quality-of-match value dependent on the quality of match between the detected time history and the respective reference time history; and

the cut of the tumbler is determined from the one or more reference time histories which produces the best quality-of-match value.

4. A method as claimed in claim **3**, wherein:

the quality-of-match value for each reference time history is weighted in favor of peaks in the detected time history which match peaks in that reference time history.

5. A method as claimed in claim **3**, wherein:

the quality-of-match value for each reference time history is weighted against peaks in the detected time history which do not match peaks in that reference time history and/or against peaks in that reference time history which do not match peaks in the detected time history.

6. A method as claimed in claim **2**, wherein:

each of the reference time histories is normalized.

7. A method as claimed in claim **2**, further comprising the step of:

normalizing the detected time history prior to comparison with the stored time histories.

8. A method as claimed in claim **1**, wherein:

the stimulating step comprises:

providing a driving transducer which moves in response to an electrical driving signal;

driving the driving transducer with an electrical pulse; and

transmitting the resultant movement of the driving transducer to the tumbler.

9. A method as claimed in claim **8**, wherein:

the detecting step comprises:

providing a detecting transducer which generates an electrical detection signal in response to movement of the detecting transducer; and

transmitting the vibrational response of the tumbler to the detecting transducer.

10. A method as claimed in claim **9**, wherein:

a common transducer serves as the driving transducer and as the detecting transducer.

11. A method as claimed in claim **9**, wherein:

a root mean square level of the detection signal is used.

12. A method as claimed in claim **9**, wherein:

a smoothed root mean square level of the detection signal is used.

13. A transducer assembly for use in determining a particular cut possessed by a tumbler of a mechanical lock, the transducer assembly comprising:

a shaft or blade for insertion into a keyhole of the lock; and

at least one transducer mounted on the shaft or blade and arranged to stimulate the tumbler by an impulse of mechanical energy and to detect vibration of the tumbler.

14. A transducer assembly as claimed in claim **13**, further including:

a gauge for gauging the depth to which the shaft or blade is inserted into the lock.

15. A transducer assembly as claimed in claim **13** for use in determining a cut of a mechanical lock, wherein:

a plurality of such transducers is provided arranged along the shaft or Wade.

16. A transducer assembly as claimed in claim **15**, further including:

a register for engaging the lock and registering the transducer assembly with respect to the lock in the longitudinal direction of the shaft or blade.

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